4th Scientific Symposium 04. – 05. 10. 2004

What is literacy? What is information? What is knowledge?

Ways of teaching and learning how to use information effectively.

Medical Knowledge, Computer Technology and Doctors

by A. Sziegoleit

Ladies and gentlemen,

first of all I would like to express my thanks for being invited to this symposium along with so many select speakers. Since I am aware that I am widely unknown in these circles, let me start with some personal remarks.

I earn my bread as a medical microbiologist at the Giessen University where I am responsible for laboratory diagnostics of infectious diseases and for the training of medical specialists in this field.

Since the beginning of 1970s, I have been an academic teacher, starting off by delivering lectures for nurses and as a supervisor during the practical courses for medical students. Later, after my postdoctoral lecture qualification, I have been standing in front of 70 to 100 students for forty to fifty hours each semester, using my voice and a lot of white chalk for writing and drawing on blackboards. In addition, addition in the true sense of the word, I have been showing a great number of slides and power-point presentations - the usual one-man show so common in the career of academic teachers and certainly no reason to get invited to this symposium. Therefore, there must be another reason.

A few years ago, at the end of the last century, the Hessian Ministry of Science and Art had the idea to supplement the education of medical students by e-learning. Some years were needed to put this splendid plan into action and I had the honour to become the first medical author in a so-called pilot project. As a medical microbiologist, I decided to create a lecture on diarrhoea. Being a complete greenhorn in e-learning technology at the time, I was instructed and supported by specialists in this field.

Later, when the Federal Ministry of Education and Research (BMBF) created the support programme “New Media in Education”, we started looking for authors in other medical subjects and for specialists in design, electronic data processing and didactics. We were successful and the K-MED project was born. K-MED is the acronym for Knowledge-based Multimedia Medical Education, an e-learning project for medical students. Its financial volume amounted to approx. 4 million Euros, enough to sustain about fifty research associates for three years.
At the beginning of the second year I became the head of this project, which is the reason why I am standing here now.

Nevertheless, being the author of e-learning courses, I am still more like a front-line fighter than a commanding officer.

Regarding medical knowledge and those who work in this field, the insider can only feel deep compassion.

In order to illustrate to you the dilemma created by knowledge, knowledge transfer or teaching, imagination, long-term memory and medical practice, I am going to use three examples.

First example:

Whenever you hear the term “Salmonella”, the name awarded to certain bacteria in honour of the American pathologist Salmon who, in 1885, discovered the pathogen in pigs suffering from severe diarrhoea, your associations will probably be the following:

Fig. 1: Man on a flush lavatory.

Even though doctors should have a slightly more extensive knowledge of epidemiology, symptoms, diagnosis and therapy, you will find something like a dark or even black box almost everywhere whenever the properties of this bacterial species responsible for salmonellosis is concerned.

When I was a student, the main focus of our lectures of medical microbiology was on how bacteria should be cultured and identified serologically as well as by their biochemical reactions. We had to study this for our exams.

Fig. 2: Biochemical Reactions.

You may agree that this row of glass tubes creates a very colourful impression. But still, did biochemical reactions bring about any understanding of the course of the illness? The answer is a clear no, in this respect that was really nonsensical.
That was in 1964. Meanwhile, thousands of papers have been written on salmonella, filling large volumes.

Fig. 3: Two volumes on Salmonella.

Does the modern student need to read and study them? And what about the books on E. coli, Staphylococci, Streptococci and any other highly interesting bacteria? Impossible! It is the job of a good lecturer to select the essentials necessary for a better understanding of the illnesses caused by different pathogens and to put them across to the listeners.

Diarrhoea of salmonellosis, the disease caused by salmonella, is usually accompanied by fever. Why is fever characteristic of salmonella infections? What happens in the gut?

Saying this, I would take a white piece of chalk in order to draw a schematic picture of the intestinal mucosa like this one.

Fig. 4: Hand drawing of intestinal mucosa.

Students should be familiar with diagrams like this from their histology lectures a few semesters ago. But when being asked what types of cells are shown here, only a minority is able to identify all of them, which makes it necessary for me to provide a repetition.

For your understanding –don't worry, this is only a very brief lecture in microbiology – the cells involved in fever reaction are macrophages situated below the enterocytes covering the mucus membrane. So when fever occurs, bacteria have reached macrophages by invading the mucus membrane. Thus, invasion is essential for the pathogenicity of Salmonella. Very simple.

The next questions are: Why and how do Salmonella invade the mucus membrane of the small intestine, how do they survive, and how are they killed? All these very complicated events (remember the thick volumes on salmonella) are summarized in two freehand drawings and the students are kindly asked to copy them.

To give you an impression, I show the corresponding figures in k-MED.

Fig. 5: Invasion of Salmonella.

At the end of the lecture students are requested to repeat the lesson at home in a k-MED course. Then applause, and the lecturer is left behind with the illusion to have helped the listeners to get a deeper insight into the pathogenesis of salmonellosis.

A few months later, at the end of the semester, the obligatory exams bring along a sad disappointment.

Second example:

Very briefly, because all of you have already heard of tuberculosis or you can ask your grandmother who will tell you that the pathogens are also called acid fast bacilli because of their many extraordinary qualities.

In order to understand mycobacteria, you have to realize that the chief constituent of the bacterial wall is mycolic acid. You may notice the phonetic resemblance between mycobacteria and mycolic acid. What is the reason? I am sure my chalk drawing will provide the answer.

Fig. 6: Hand drawing of mycolic acid, a candle and the crystalline structure of mycolic acid.

Mycolic acid is a branched aliphatic carbohydrate with an extremely long carbohydrate chain comprising up to 90 carbon atoms. In addition, these molecules are packed up in a crystal-like arrangement.
In order to get an idea of this structure, please imagine a simple candle made of stearin, an aliphatic chain of only 18 carbon atoms. In conclusion, mycolic acid must be 5 times as solid and hydrophobic as a simple candle.

To the same extent as you are aware of these extraordinary features of mycobacteria, you will get an idea of the complicated pathogenesis of tuberculosis, the specific immune reaction of the host and the difficulties concerning diagnosis and therapy. Thus, mycolic acid is the key substance for understanding bacteria and the illness they produce.

Again, at the end of the lesson, students are invited to repeat tuberculosis at home in a k-MED course. Applause, and the lecturer is left behind with the illusion to have helped the listeners to get a deeper insight into tuberculosis.

A few months later, a multiple choice question on mycolic acid is answered correctly by two of 80 students

Third example:

A very complicated one, I have to admit, but never mind, no one really knows. This example does not focus so much on students, but on medical experts.

I am referring to the interaction between molecules and cells, a basic reaction of life. The molecules may be certain bacterial products, cytokines, interleukines or hormones. We don’t need to be so accurate.

In any case, the primary event is the attachment of the molecule to a specific receptor on the cell surface. In the case of a cell reaction, the cell changes its behaviour.

This means that a lot of genes, say 30 to 50, are switched on or are up regulated while others are switched off or are down regulated in answer to a highly sophisticated cascade of signals. Be assured, thousands of scientists all over the world are occupied with shedding light on some stages of these marvellous reactions

As an example you can see a very simplified model of the signal cascade initiated by the bond of a cytokine, in this case of tumor necrosis factor, to a cell.

Fig. 7: Signal cascade.

On this foil slide, only the first few steps within the cytoplasma are shown. The following reactions within the nucleus, which bring about the cell reaction, have been omitted.

What you learn, and that is the only thing a practitioner has to learn, is that cells are extremely complicated units and mankind is very far from understanding them. Therefore we have to handle cells with great respect, being aware that we know little to nearly nothing.

Why am I using this as my third example?

The elderly woman of, say, about 50, knows it best.
In the middle of the nineties a wonderful, better, fantastic message was directed to all these ladies: All discomforts and sufferings, present and future, including coronary heart disease and osteoporosis, can be prevented! You only need to swallow a little

pill every day for the rest of your life. And, best of all, no undesired effects are to be expected.

This marvellous efficacy was attributed to a mixture of estrogen and gestagen closely resembling that of contraceptives. What aroused serious discussions and warnings with regard to younger women at that time, seemed to be solely beneficial for the elderly. No wonder that all specialists, the ultimate authorities of gynaecology, recommended this little pill in unison.

I am sure you are informed of the later development. Except for the benefits during the menopause, everything else proved to be wrong. Even worse, breast cancer, coronary heart disease and osteoporosis increased rather than decreasing so that now the prescription is accompanied by many warnings.

Why were experts so optimistic? I don't want to dwell on the tempting economic aspects. I can only assume that these specialists had no idea how molecules act on cells, in this case on cells of very different organs including the heart and bones. So they credulously and carelessly believed in the preliminary results of only few clinical trials.

Now they ought to be a little bit ashamed of this, but I am afraid that admission of ignorance is incompatible with leadership.

Why is it so difficult to translate words or terms into images closely, or at least roughly, resembling scientific findings?

I believe that the problem is that you have to enter a real but abstract world beyond all experiences. Being able to enter this huge area requires hard work and depends on the power of imagination, sustained by curiosity, interest and multiple repetition.

Before this audience it is unnecessary to explain or better to speculate on how long-term memory is developed.

In any case, it is essential to focus on a subject for a longer time-period and with one, or better, with several different senses, i. e. by means of hearing/listening, writing, speaking and drawing. I hope you will understand what I mean if I count writing and drawing among the senses.

The more senses are involved, the better the expected result.

In traditional lectures, learning and memorizing are achieved by means of listening, writing and drawing. That's why I waste so much chalk in my lectures and try to encourage students to copy what I have written and drawn on the blackboard.

To my astonishment, an increasing number of students have been sitting in their seats behind clean tables with folded arms and motionless faces for several semesters. Nevertheless, they keep coming to my lectures.

I have no real proof that these students are really the worst in the class. But I would find it hard to believe that they represent our most intelligent individuals who may not

need the cooperative action of the neuronal networks from different brain areas to anchor knowledge for a longer time period.

I fear that an increasing number of people, including students, who are accustomed to a flood of information delivered by television, the internet, short messages, newspapers, magazines, video clips and so on are unable to work their way through a single theme unless their imagination has engraved real pictures in the ultimate depths of their cerebral convolutions.

Or does this not appear to be necessary any longer?

The term “information society” makes them believe that knowledge is always available, always present. Even though this is true, knowledge is reduced to superficial information resembling “fast food information” or McInfo.

Modern industrial society – the audience excluded - becomes a victim of the advance of information technology. Supported by an overwhelming mass of information, people become more and more ignorant.

This sounds deeply pessimistic but it may prove right for the majority of people - for the majority of doctors, too?

I don’t want to damage the reputation of my colleges. I have already mentioned the compassion we have to feel with them. Remember the three examples I told you about.

The doctor should have to draw several hundreds or thousands of molecular scenes in order to gain a deeper insight into the events leading to illness or cure as the desired reaction to the pills he has prescribed.

So far I have looked at doctors with the eyes of a laboratory scientist who is totally free from medical attendance, instrumental interventions, talks with relatives, station organisation, etc.

I am sure that all of you have had, more of less often, your personal experiences with some members of this profession and I am sure that they did not only do their personal best but indeed the best to earn your satisfaction.

So the question is if it really makes sense to demand cellular and molecular understanding from them. In other words, what is more important, knowledge or experience? The main thing is that doctors do it right, or don’t they?

Here, I would like to come forward with a proposal of how computers could help them to sustain their experience or to improve their work.

Allow me to return to the unappetizing topic of diarrhoea. Imagine the situation of a diarrhoea patient seeing his doctor in hope of a cure.

Imagine the doctor feeling into his pocket to get out his palmtop computer. He types the term “diarrhoea” as the basic symptom into his computer. In return, the computer immediately offers him a list of questions he has to address to his patient, for

example like these:

Fig. 8: Palmtop computer with check list

Each question is associated with those pathogens, which are suited best to the given symptoms or specific circumstances. So far, I have mentioned fever and salmonella. Here, in addition, we differentiate between high and low fever, which is an indicator for different salmonella species.

Other symptoms and circumstances, for example bloody and mucous stools, low fever and poor sanitary conditions indicate shigella. At the same time, local epidemics accompanied by low fever suggest viral infections and so on.

The strategy is clear: Once the doctor has started off using specific questions, the range of possible diagnoses is limited depending on their probability.

In a second stage, the computer presents a new chart containing new questions, examinations and laboratory tests which help to eliminate some of the remaining alternatives until the final diagnosis is confirmed.

The following stage suggests therapies which, with the help of further questions, are adapted to the individual patient.

It is self-evident that such computerized questionnaires can be easily adapted to other basic symptoms such as headache, high blood pressure, chest pain, cough, etc.

In any case, the computer will be the doctor’s guide through the maze of differential diagnoses.

Every use of the computer will systematically teach him to reflect the possible pathogenic events that lead to the exact symptoms of his patient. By means of repetition, he will gradually remember some of the essentials he learned long ago. If the use of the computer becomes a matter of routine, his knowledge will increase by small degrees.

Such computerized assistance has not the aim to incapacitate the practitioner but to assist him on the long and winding road of curing patients from a wide range of medical conditions.

Some attempts have already been made to generate such systems for palmtop computers. But the systems available at present are far from satisfactory in daily practice. So further research and development is required to achieve this aim.

With the help of such a marvellous machine, even a really incompetent doctor will be able to save lives.

Thank you very much for your attention.

Medical Knowledge, Computer Technology and Doctors

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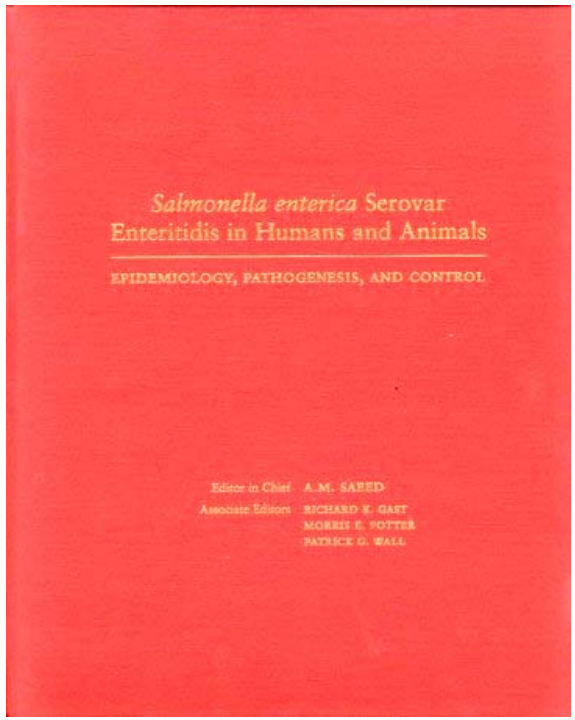
Salmonella

Biochemical Reaction

Knowledge about Salmonella



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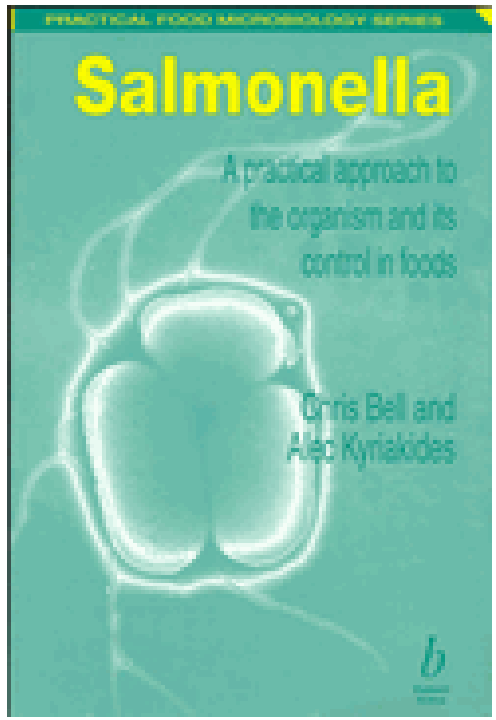

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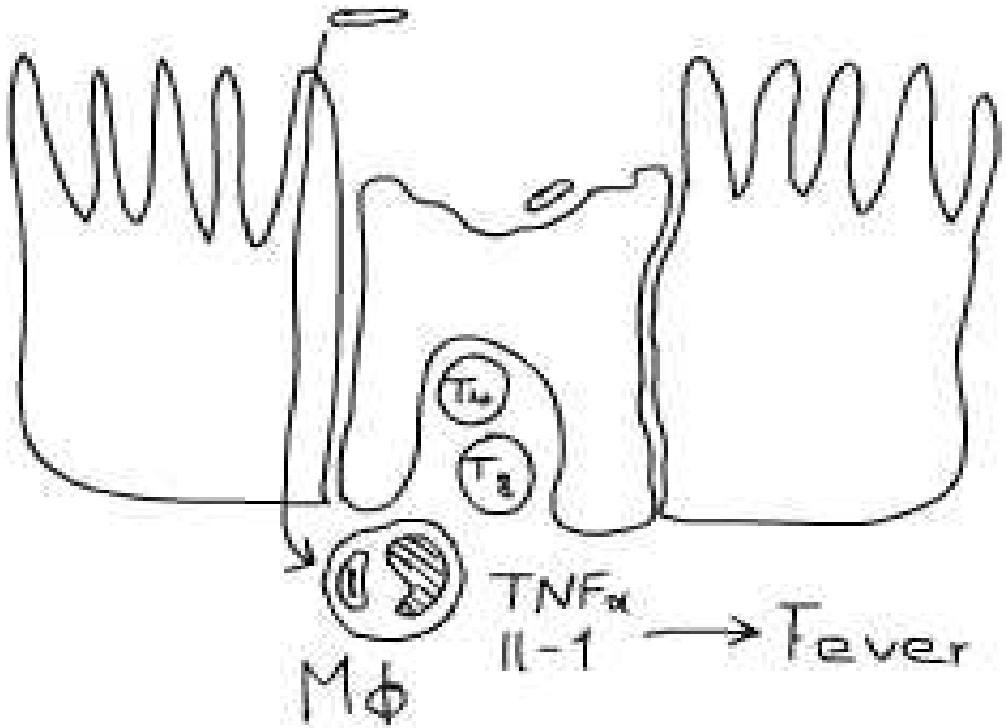
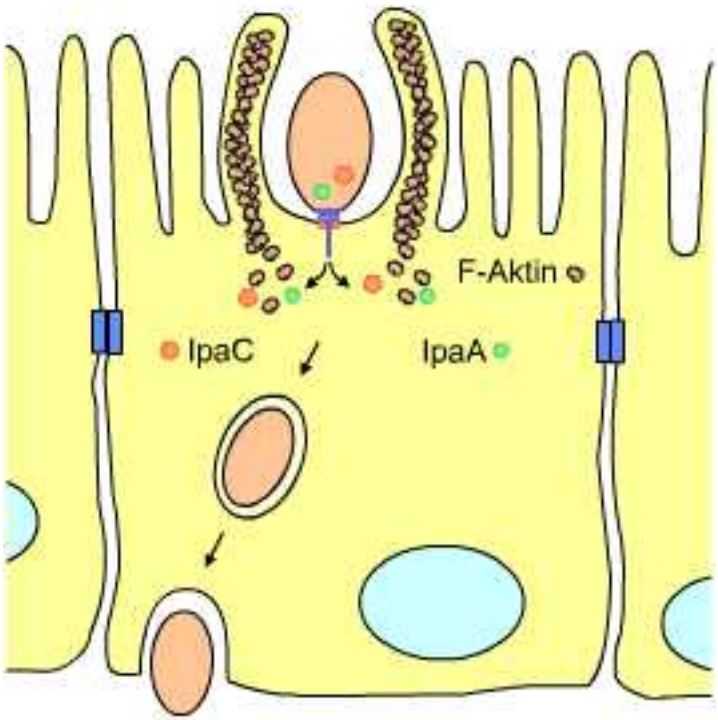
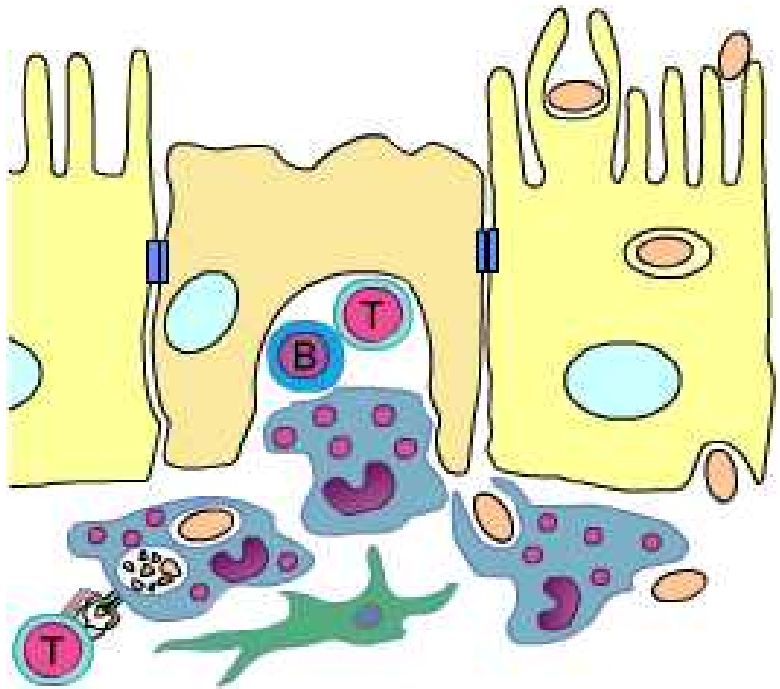
Fever as Outcome of Invasion

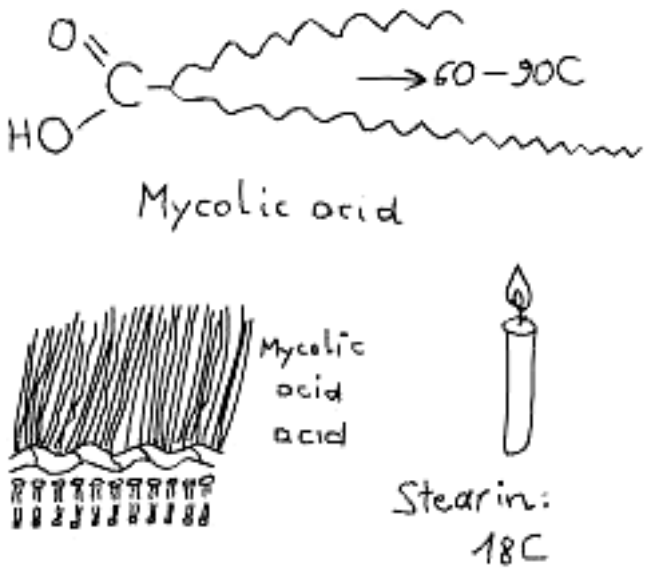


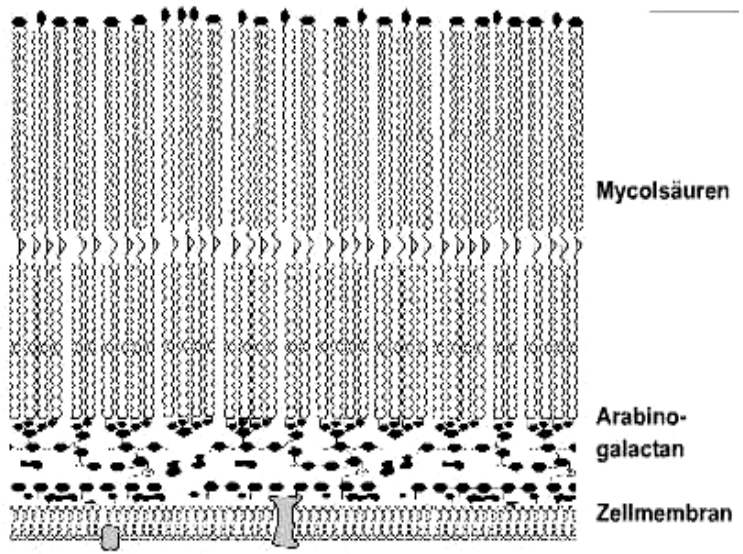
Invasion and Killing of Salmonella by Activated Macrophages



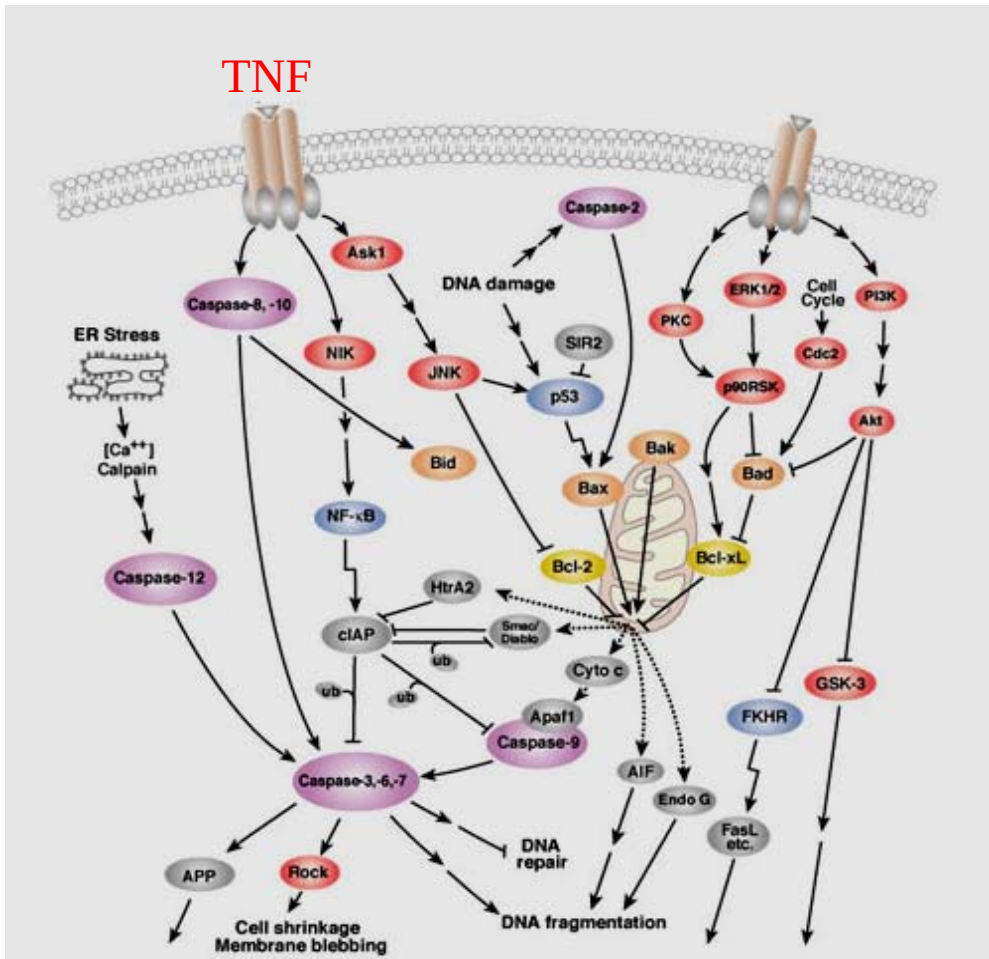


Mycolic acid in the Cell Wall of Mycobacteria





Signaling Cascade induced by TNF



Diagnostic Expert System